CABANIS

The Irrigation of the Uintah Indian Reservation, Utah

Civil Engineering

B. S.

1908

THE IRRIGATION OF THE UINTAH INDIAN RESERVATION, UTAH

BY

JOHN BRAHM CABANIS

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1908

UNIVERSITY OF ILLINOIS

June 1, 1908

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

JOHN BRAHM CABANIS

ENTITLED IRRIGATION OF THE UINTAH INDIAN RESERVATION

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Civil Engineering

John P. Brooks
Instructor in Charge.

APPROVED: Ira O. Baker.

HEAD OF DEPARTMENT OF Civil Engineering

Introduction.

The reclamation of millions of acres of land from vast Western areas of arid desert waste and its transformation into tillable fields of loamy wealth and productive fertility by the great systems of irrigation, has lifted to the level of national recognition and importance this stupendous enterprise with its attendant opportunities and problems in engineering and its significant industiral and social possibilities.

What the recovery of desolate prairies to valuable and fertile farms offers in engineering feats is becoming to be fully realized; what it means industrially and economically is rapidly approaching comprehension; but the magnitude of its importance as a factor in the civilization it creats is seldom embraced in the ordinary conception of the colossal influence and benificence the miracle of irrigation will confer upon the present civilization in opening these vast areas of Western land to cultivation and settlement.

To furnish an adequate water supply to millions of acres of fertile land in the arid regions of the West means that an outlet has been provided for at least one million people to seek new homes, to create new wealth, to build new towns, and to otherwise increase the aggregate strength of the nation. In no part of the country has permanent wealth been created more rapidly than in the reclaimed portions of the West.

What has been done by private enterprise in irrigation is but a slight indication of what can be done by public control. Sev-

eral million acres of land under irrigation are now open for settlement in the United States as a result of private enterprise, and as a result of the irrigation law the Government is now engaged in constructing irrigation works to provide a water supply for more than a million acres of arid land. This immense area of fertile and productive land provided with irrigation will cause an astonishing influx into western country during the next few years.

Irrigation compels the adoption of the small farm unit. This is the gem of its new social possibilities. During the first and second eras of colonization in this country, the favorite size of a farm was about four hundred acres, of which from a fourth to a half was gradually cleared and the rest retained in woodland. The Mississippi valley was settled mostly in quarter-sections, containing one hundred and sixty acres each. The productive capacity of land is so largely increased by irrigation, and the amount which one family can cultivate by its own labor consequently so much reduced, that the small farm unit is a practical necessity in the arid region. Where settlement has been carried out upon the most enlightened lines irrigated farms range from five to twenty acres, rarely exceeding forth acres at the maximum.

The irrigated sections of the West present almost ideal rural conditions. A twenty acre unit means that neighbors will be eight times as numerous as in a country settled in quarter sections. The tendency is, where water is used for farming, to subdivide land into small individual holdings, which gives to a community a prosperity and stability not found in larger farming districts, nor in cities. It is highly probable that there will be a gradual spreading eastward of irrigated methods and this will eventually result

in the subdivision of great numbers of large eastern and southern farms and plantations, which are now farmed without thought of artificial water supply, into smaller irrigated farms.

The irrigation, then, of one hundred million acres of Western plains and valleys, while it will create innumerable small rural homes andrequire vast engineering projects, will serve further to encourage subdivisions of larger areas in the east and south, where they are beginning already to think of supplementing the natural water supply.

Irrigation in the west has just begun. Its development i is not merely the result of a succession of victories in engineering skill over physical impediments. The greatest obstacles encountered are those arising from the inapplicability of out laws and customs to the conditions prevailing within the arid regions. A commerce in water of immense and constantly growing importance has been created. Lawyers and judges are struggling with the complex legal problems growing out of stream ownership where "appropriations" are regulated by statute, and still worse complications which exist where the retention of riparian rights has been attenpted.

Strange it is but the scientist has proved it true that when you take a little patch of sand such as is found in some of the deserts in the west and allow water to soak in it, a combination is formed from which the plant or stalk springs more vigorously even than from the dark, rich soil water by rainfall and dew. Many of what are termed "staple" crops are not as abundant as when grown in ground naturally irrigated as when planted in the field or garden rescued from thebarrens. As an example of this,

the following figures compiled by an expert in the Department of Agriculture of the United States, is cited: Pennsylvania, Ohio, Indiana and Illinois, are noted for their fertile farms and abundant harvest. He compares this corner of the country with Idaho, Colorado, Arizona, Nevada, New Mexico and Utah, where the water has been diverted to flow over what was once a sterile plain. Each harvest for ten years in this region of irrigation yields an average of one bushel of wheat more to the acre, two bushels of rye, two bushels of barley, seven and one half bushels of potatoes, than did those for the same period in the four states on the other side of the Mississippi. The expert also proved that the farmer who cast his lot on the border of the arid land had produced one bushel of wheat to the acre, one of oats, two of rye, one of barley, and eleven of potatoes, more than the average yearly harvest of the whole country during the same period.

Irrigation has so improved the productive capacity of the land of Utah that the farm unit is twenty acres. This supports a settler and his family in more than ordinary comfort. A townsite of the same land would not produce enough to keep this settler from starving if compelled to cultivate it in its original condition.

One of the most interesting results of irrigation in social and economical way, is its influence upon the density of the population. The densest population in eastern states obtains in Rhode Island where there are two hundred and seventy six people to the square mile. In a representative locality of southern California which is in the midst of the loder settled irrigated districts, there are five hundred persons to the square mile, practically all of them engaged in horticulture by me ans of irrigation.

There is, therefore, no rish whatever in predicting that the arid lands of the west will ultimately sustain much the densest population of the United States.

The Uintah Indian Reservation.

The Uintah Indian Reservation, belonging to the Uintah, Uncompahgre and White Rive Ute Indians, comprises one million thirty nine acres of land; about four hundred thousands acres of which is susceptible of irrigation.

In September 1904, a Commission was appointed by the Secretary of the Interior for the purpose of making a survey of the Reservation and alloting the most desirable lands to the Indians for agriculture and grazing purposes, and throwing the remainder open to "homesteaders".

The Commission, consisting of the United States Indian Agent, Superintendent of Irrigation for the Department of the interior, and the State Engineer of Utah, after making a thorough survey of the Reservation, alloted one hundred and twelve thousands acres of land, susceptible to irrigation, and two hundred and fifty thousand acres of land, suitable for grazing purposes, to the Indians, the amount of land alloted to each being as follows:

Males, with family,	160 Acres.
Males, without family,	80 "
Females, single,	80 "

At the same time the survey was made, sufficient data was collected in order to make application to the State Engineer for Water Application.

In August, 1905, the Reservation was thrown open to home-

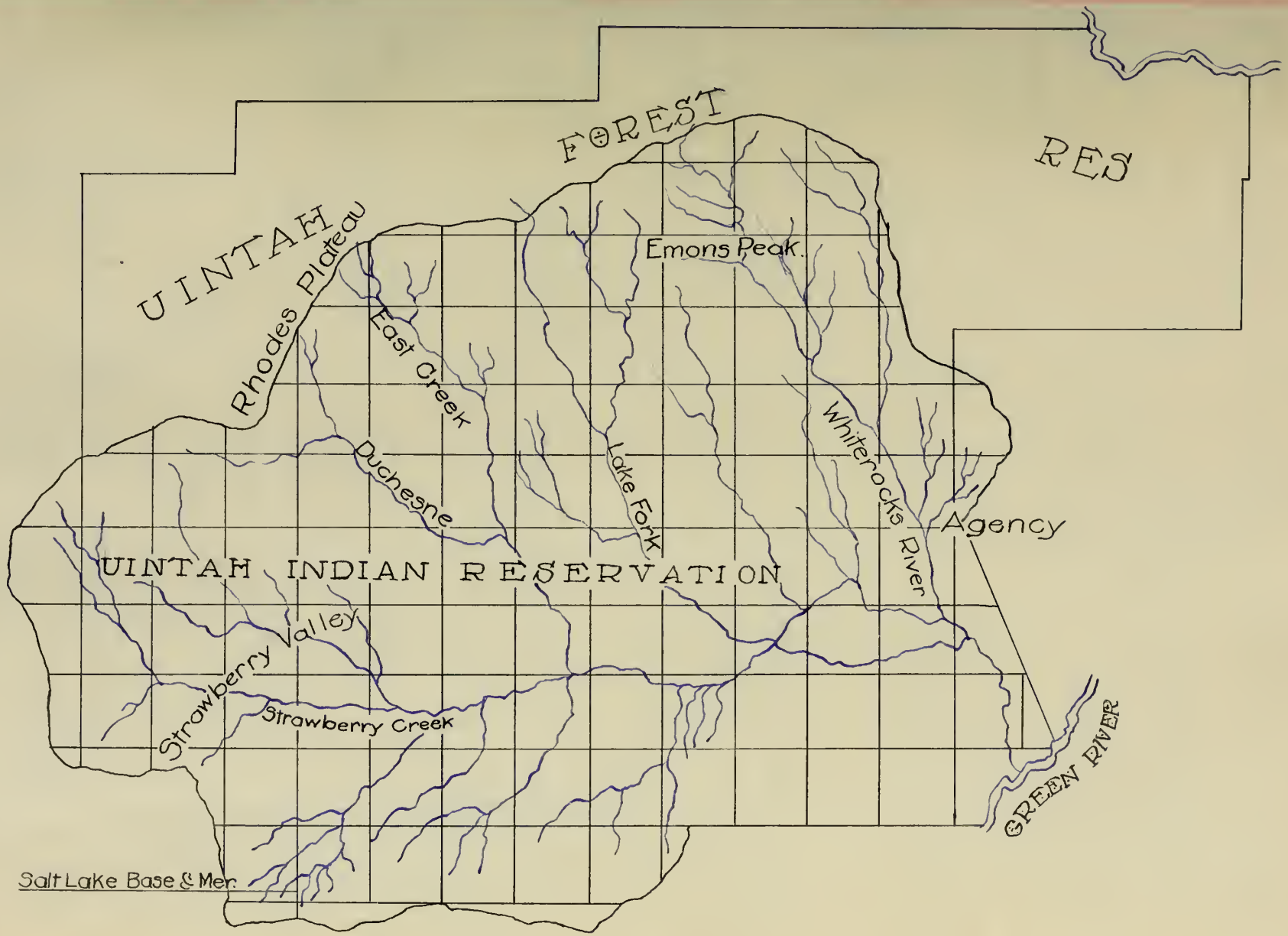

FOREST
RES
UINTAH
Rhodes Plateau
Emons Peak.
East Creek
Duchesne
Lake Fork
Whiterocks River
Agency
UINTAH INDIAN RESERVATION
Strawberry Valley
Strawberry Creek
GREEN RIVER
Salt Lake Base & Mer.

PLATE 1.

steaders and at the present time, the population of the valley is about equally divided.

The Reservation is situated in the Northeastern part of the State of Utah. It embrases as fertile a a valley of agriculture land, as can be found anywhere in the intermountain region. The Reservation is about seventy-five miles long, north and south, and thirty miles wide, east and west. On the south it is bounded by the high single spur range of the Wasatch Mountains, while on the north, the lofty peaks of the Uintah Mountains form its biundary.

The arable land is cut up by inumerable small creeks and streams which flow, as a general rule, throughout the entire year. The water of these streams, being fed by the melting snow in the canyons of the Uintah Mountains, contains practically no alkaline whatever, and this fact, together with the natural slope of the country, makes irrigation not only profitable, but practicable.

The altitude of the irrigable land above the sea, varies from fifty nine hundred to sixty three hundred feet. It is a typical mountain desert country with its characteristic stretches of sand and sage-brush, its cloudless skies and scorching sun.

In general, the soil distribution is quite similar over the entire Reservation. Surrounding the valley and lying next to the foot hills are, what are termed, "bench lands", or simply benches. These benches mark the shore line of the ancient Lake Bonneville, the water of which, in prehistoric times, covered the greater part of the interior basin of the present state of Utah. They have been formed by a heterogenous mass of disintegrated.

stone and gravel, washed from surrounding country and are of a gravelly nature, varying from three to four feet in depth in some localities. The sub-soil is generally a loose, coarse gravel with an occasional layer of gravelly cement. In the central portions of the valley, the soil is more sandy and the sedimentary deposits are quite deep, forming a rich, heavy soil, having, as a general rule, a stiff clay sub-soil.

In all these valleys, the bottom lands were almost without exception, the first to be reclaimed and cultivated, not because the soil was the best, but because it was more easily watered. As the higher lands came under irrigation, and the excess of water used in their irrigation began to manifest itself in the form of seepage, the bottom lands became too wet for successful irrigation, and were converted into meadows, which are used as hay lands and for pastures.

The inhabitants of the Uintah Indian Reservation, are for the most part, Ute Indians, but the population is being rapidly increased by the invasion of white "homesteaders". It may safely be said that the Indians, to a great extent, are rapidly adapting themselves to civilization and taking advantage of the great opportunities offered by the Government in supplying them with water, by which farming on a profitable basis is made possible. The Government keeps in its employ, several practical farmers who are constantly among the Indians, teaching them methods of modern farming and acquainting them with the many details incident to successfully growing crops by means of irrigation. Very few of the white farmers on the Reservation own the farms upon which they live. For the most part, they lease the land from the Indians for a very

small amount. By leasing "Indian Lands" the farmer has at his immediate command, all the water that he can possible use and also the most desirable land on the Reservation.

According to the United States Laws covering water rights on the Reservation, none but Indians can obtain water from the Government Ditches, (except in the case of leased lands) but any one can enlarge a Government Ditch, or any other ditch, and convey water through it, providing he has a proper water right granted by the State. But this necessarily entails a large outlay of money, which, in most cases, would not warrant the farmer in making the expenditure. By leasing Indian Lands for a very small amount, and thus securing water rights free of charge, the farmer stands in a fair way to secure amply returns on his money.

The principal crop raised on the Reservation is alfalfa, although a considerable quantity of oats and sugar beets are cultivated, but as the demand for the latter, at the present time, due to the sparsely settled country is small, only a limited quantity is raised.

Drainage Area.

The DuChesne River rises in the high peaks of the Uintah and Wasatch Mountains, flows in a general southeasterly direction and enters Green River three miles above the mouth of the Whiterocks river. It is a very crooked stream, swinging back and forth across the valley, its course in general, being marked by a thick growth of cotton-wood trees.

The principal tributaries of the Du Chesne River, are the Strawberry, East and Lake Creeks, and the Uintah River. The val-

ley of the Du Chesne, is about two miles wide and is bordered on both sides by sandstone bluffs, approximately two hundred feet wide. The cliffs on the north side of the river are capped by a heavy deposit of coarse gravel and cobble stones.

The Uintah River, and its principal tributary, the Whiterocks River, have their sources in a series of lakes in the Uintah Mountains, fed by the snow that exists the year around in the canyons and on the high slopes. The upper drainage of these streams is very mountainous and difficult of access. After leaving these canyons, about seven or eight miles above Whiterocks, the Indian Agency, the river flows South-westward, uniting in various channels between the Agency and Ft. Duchesne, from which point they flow in one channel.

Climate.

The records of the United States Bureau show that for a period of more than nine years, from 1893 to 1901, the mean annual precipitation to be 6.31 in., and the mean annual temperature 56.7 degrees, the year of greatest rainfall was 1897 when 9.81 in., fell; and the lowest rainfall, 1894, when only 3.55 in., fell. During this period, the months of least mean precipitation were, in order, June, September, November and May, and the greatest mean precipitation; August, February, June and March. The lowest monthly mean was 0.1 in., in June and the highest 1.11 in. in August. There has been no year in the nine which at least one month was not devoid of precipitation. In five months, in 1894, four months in 1898, two months in 1893, 1895, 1897, 1899 and 1901, the total precipitation was not over 0.01 in., and in some of these months there was no precipitation whatever. The greatest fall for any

one month during this period was not over 2.98 in., which occurred in July 1896.

From the above data, it is plain that on the Uintah Indian Reservation, the rainfall is light all the year, but the lightest the last of spring and the beginning of summer and in the fall; that the temperature is devoid of low extremes in summer, and that most of the days are clear. It is therefore a region well adapted to agriculture and irrigation.

Methods of Irrigating.

In irrigating by flooding, field laterals are run out from the head ditch, seventy-five to one-hundred feet apart, on a grade of 0.50 to 0.75 of an inch to the rod, or from three to four and one-half inches fall in every hundred feet. These laterals are large enough to carry the head used, which may vary from fifty to one-hundred miner's inches, and are made at the time the crop is planted. One irrigator can attend the two streams which are kept running in adjacent laterals. At given distances, varying from seventy-five to one-hundred feet, he places some temporary dam in the channel which stops the flow in that direction and causes it to flow over the low places in the bank. The dam used may be of metal or canvass, or it may consist of a pile of coarse earth. The water is allowed to run until the upper foot of the soil is saturated, any excess which runs off being caught by the lower laterals. By this method, one man in ten hours will irrigate from two to five acres.

In irrigating by the check system, the land is "checked" and the labor and expense of irrigating is much reduced. A large

head of water is used, which is turned into a check by simply raising a wooden check. When sufficient water has been admitted, a gate to the next check is opened and the first one closed. Two men in twelve hour shifts should irrigate on the average, fifteen acres per day.

In irrigating by the furrow method, furrows from three to six inches deep and from two to four feet apart are constructed. Each furrow is fed by a wooden spout placed in the head ditch. The cost of irrigating by this method is estimated to be about the same as flooding from laterals, but it can be used successfully only in soils that wash readily when flooded and crust forms on the surface after each wetting.

The Uintah Irrigation Project.

The following is a copy of the appropriation made by Congress for the construction of the Uintah Irrigation System:

Public Notice No. 258. In making appropriation for the current and contingent expenses of the Indian Department for fullfilling treaty stipulations for various Indian tribes, and for other purposes, for the fiscal year ending June 30th, 1907.

For constructing irrigating systems to irrigate and alloted lands of the Uncompahgre, Uintah and White River Utes in Utah, the limit of cost of which is hereby fixed at six hundred thousand dollars; one-hundred and twenty five thousands of which shall be immediately available, the cost of said entire works is to be reinfursed from the proceeds of the sale of the lands within the former Uintah Indian Reservation: provided,

That such irrigating systems shall be constructed and

completed and held and operated, and water thereof appropriated under the laws of the State of Utah, and the title thereto unless otherwise provided by law, shall be held by the Secretary of the Interior for the Indians, and he may sue and be sued in matters relating thereto; and provided further,

That the ditches and canals of such irrigation system, may be used, extended, or enlarged for the purpose of conveying water for any person, association, or corporation, under and upon compliance with provisions of the laws of the State of Utah.

And provided further: That when said irrigation systems shall be in successful operation, the cost of operating same shall be equitably apportioned upon the lands irrigated, and, when the Indians have become self-supporting, to the annual charge shall be made an amount sufficient to pay back into the Treasury of the United States, the cost of the work done, in their benefit, within thirty years, suitable deductions being made from the amounts received from the disposal of the lands within the former Uintah Indian Reservation.

Canals under the Project.

Below is shown in detail the number of ditches, length, top and bottom width, acreage supplied, grade and second feet of water that each ditch is to carry under this project:

No.	Name	Length	Top	Bottom	Acreage	Sec. Ft.	Grade.
1.	Bench Ditch	42249 42200	18	12	3680	75	7.50
2.	Deep Creek	42200	20	10	7320	105	10.56
3.	East Whiterocks	25000	18	6	4720	75	10.56
4.	Farm Creek	21200	12	4	2240	32	21.10

5. Ft. Duchesne	24100	10	4	1280	15	5.25
6. Henry Jim	80000	15	8	6240	50	10.56
7. Uintah	24000	22	12	11720	142	10.56
8. Lake Fork	30300	21	12	10000	143	10.56
9. Red Cap	31680	21	10	10000	110	5.28
10. Pacease	17500	10	4	17200	23	5.28
11. Strawberry	2000	8	4	360	7	19.56
12. Myton	5280	14	6	5280	50	1.00
13. Theodore	19560	9	4	400	8	1.00
14. Whiteriver No. 1	32000	16	8	1020	15	1.00
15. Whiteriver No. 2	69000	14	12	4280	62	5.28
16. John Henry	15840	8	4	200	5	5.28
17. Jasper Pike	31000	12	6	1500	22	5.28
18. Ganawards	6600	7	4	160	3	5.28
19. Norwitch	18480	9	4	720	10	5.28
20. Gray Mountain	31680	10	4	1200	15	20.00
21. Indian Villiage	55540	8	5	54400	52	5.28
22. Ouray School	32200	10	8	5480	52	2.64
23. Dry Gulch	63360	18	8	7160	55	10.56
24. Patcheek	15840	8	4	340	8	10.56
25. Appowite	42240	11	5	1840	20	19.25
26. Wasatch	52280	15	6	1120	12	10.56
27. Leland	26400	12	6	1880	20	5.28
28. Uintah No. 2.	5000	20	10	3320	50	21.12

State Law Covering Application to Appropriate Water.

The following extract from the State Laws of the State of Utah governing Water Rights, will go to show in a general way, the

requirements for obtaining the right to use water:

Section 35. Application To Appropriate: Any person, corporation or association, to hereafter to acquire the right to the use of any public water in the State of Utah, shall before commencing the construction, enlargement, or extension of any ditch, canal or other distributing works, or performing similar work, tending to acquire the said right, or appropriation, shall make an application in writing to the State Engineer, which shall include a map, profile and drawings, as hereinafter provided. Such application shall be upon a blank furnished by the State Engineer, and shall set forth the name and post-office address of the person, corporation or association, making the application; the nature of the proposed use for which the application is intended; the flow per second of the water to be used, and the time during which it is to be used each year; the name of the stream or other source from which the water is to be diverted; the place on such stream or source where the water is to be diverted, and the nature of the diverting works; and the dimensions, grade, shape and nature of proposed diverting channel; and such other facts as will clearly define the full purpose of the proposed appropriation.

If the proposed use is for irrigation, the application shall show in addition to the above required facts, the legal subdivisions of the land proposed to be irrigatedd, with the total area thereof, and the charcter of the soil.

Water Application.

A fac-simile of a water application for the Deep Creek Canal is shown below, and will serve to make clear the requirements

of the State of Utah before a water right can be obtained:

"For the purpose of acquiring the right to use a portion of the unappropriated water of the State of Utah, application is hereby made to the State Engineer, based upon the following, showing facts, submitted in accordance with the requirements of Chapter 198 of the Session of the Laws of Utah, 1905.

The purpose for which the water is apportioned is - Irrigation.

1. The name of the applicant is - C. G. Hall, Acting Agent for the Indians of the Uintah, Uncompahgre and White River Reservation.

2. The post-office address of the applicant is - Whiterocks, Utah.

3. The flow of the water to be used, is in cubic feet per second - 195.

4. The quantity of water to be used is - (See note under "Explanatory")

5. The particular point at which the water is to be diverted is - The headgate is located at point of diversion on the left bank of the Whiterocks Creek, a tributary of Green River, which lies sixty-eight degree, fifty-eight minutes west, fourteen hundred fifty-nine feet from the Southwest Corner of the N..E. one fourth, o of the N. E. one-fourth, of section 5, Township 1, Range 1 East, a subdivisional corner, Uintah Special Base and Meridian.

6. The water is diverted from - The Green River System in Uintah County, Utah.

7. The diverting works will consist of - a substantial headgate, a canal, and a diverting dam where necessary.

8. The cross section of the diverting canal will be

9. The nature of the diverting channel will be -earthern.

10. The length of the channel will be - 4200 feet.

11. The top width of the diverting channel will be - 20 ft.

12. The bottom width of the diverting channel will be 10 feet.

13. The depth of the water in the diverting channel will be - two and one-half feet.

14. The grade of the diverting channel will be - 10.56 ft. per mile.

15. The legal subdivisions of the land to be irrigated are as follows: Indian Allotments in the following Sections; Sections 1, 2, 3, 11, 13, 14, 23, 24, 25, 26, 35, 36, Township 1, South Range 1 East; Sections 1, 2, 11, 12, Township 2, South, Range 1 East Sections 6 and 7, in Township 3 West, Range 1 East of the Uintah Special Base and Meridian.

17. Character of the soil in above tract of land is - Landy Loam, the subsoil being Gravel and Boulders.

18. Acreage - 7680.

"Explanatory" The appropriation is for the purpose of irrigating Indian Allotments of the Uintah Indian Reservation in Utah, made under the Act of May 27, 1902. At Station 195, the canal reaches a deep soil country and the grade is therefore reduced from 19.56 to 5.28 feet per mile, to prevent excessive erosion.

The Deep Creek Canal.

The Deep Creek Canal is taken from the Whiterocks River, about four miles north of Whiterocks, and irrigates about 6780 acres

of land. The construction of this ditch was commenced in June, 1906, and completed the following September.

The alignment for the first thirty nine stations is through boulders and gravel, crossing three old river channels and a swamp. From Station 80, to Station 118, the line winds around the hills, the material here consisting of loose rock, boulders and gravel and some solid rock. At Station 118, it passes through a saddle in the hills and enters a small valley where the first allotments are located. At Station 194, the line crosses a deep coulee where a flume, one-hundred and twelve feet long is located. At Station 194, another flume, one hundred and eighty-four feet long is built to carry the water across a second coulee. From Station 210 to Station 250, the line hugs the hills again, and the excavation consists of solid and loose rock and indurated earth. At Station 250, the line enters another valley which is traversed by two washes which are flumed. Crossing these, it swings into the hills on the other side. Station 295 to Station 307 is a hillside work, consisting of loose rock, gravel and indurated earth. The fifth flume is located at Station 364 and from here to Station 506, where the ditch crosses Deep Creek, on flume No. 6, the excavation consists of loose rock.

From Deep Creek to Station 593, where the ditch empties into a rocky wash, the excavation is through earth.

The ditch has thirty-two structures including the headgate and a check waste gate located at Station 52.

The classification of material and cost of construction is as shown in the following table:

2053.8	Cu. Yds.	Loose Rock at 50 cts.	$1026.90
2889.0	" "	Wet Excavation at 50 cts.	1444.50
8112.5	" "	Boulders & Gravel at 40 cts.	3244.88
6417.0	" "	Gravelat 25 cts.	1604.25
84415.2	" "	Earth at 19 cts.	16038.88
106502.5	" "	Excavation	25974.71

Structures.

170,000	Board Feet lumber at $11.00 per M.	$1870.00
	Hauling above from Mill	2040.00
	Wages of employees	4848.12
	Total	8758.12
	Cost of excavation	25974.71
	Grand Total	34726.83

Cost of irrigating 7680 acres of land - $4.82 per acre.

Flumes.

Flumes are always employed where the canal crosses a dry wash or coulee. (They are also employed where the line crosses of passes around a steep rocky hill side). These coulees, during a certain period of the year when freshets occur, run full of water, while later on in the season, they are dry, being only distinguished by the depression they cause and the character of the soil. In order to protect the canal from being destroyed during the high water, they are flumed as above. It is very necessary to carefully study the discharge that occurs in the coulee, in order that the flume is carried high enough to allow the water in the coulee

to pass underneath. (The state laws require a clearance of one foot and a half). The foundation for the flume must be substantial and the area of the waterway must not be greatly impeded; other wise, the velocity of the water in the drainage channel will be so great as to cause scour of its bed and perhaps destroy the flume. The flumes are constructed as shown in the following sketch of page 20. It will be observed that the connecting ends are well bulk-headed so that leakage will not occur at these points.

The drawing referred to above shows that the floor is built directly upon stringers, the planking being placed parallel to the current of the stream. The lumber employed is never less than two inches in thickness.

Laterals and Lateral Gates.

When possible, laterals are run on each section and quarter section line crossed by the ditch. When the lay of the land will not allow of the above construction, the laterals are run on a contour line.

All laterals are built one-foot deep with a width varying from four to eight feet, this width depending upon the amount of water that is to pass through them. The laws of the State of Utah, require one second foot of water to supply seventy acres.

The velocity of the water in the laterals cannot exceed three second feet. If the velocity of the water, owing to the e excessive fall of the country, is greater than this limit, drops are mployed, thus reducing the grade to the required amount.

The laterals are caefully laid out in such a way that, the water shall ultimately be brought to within three miles of

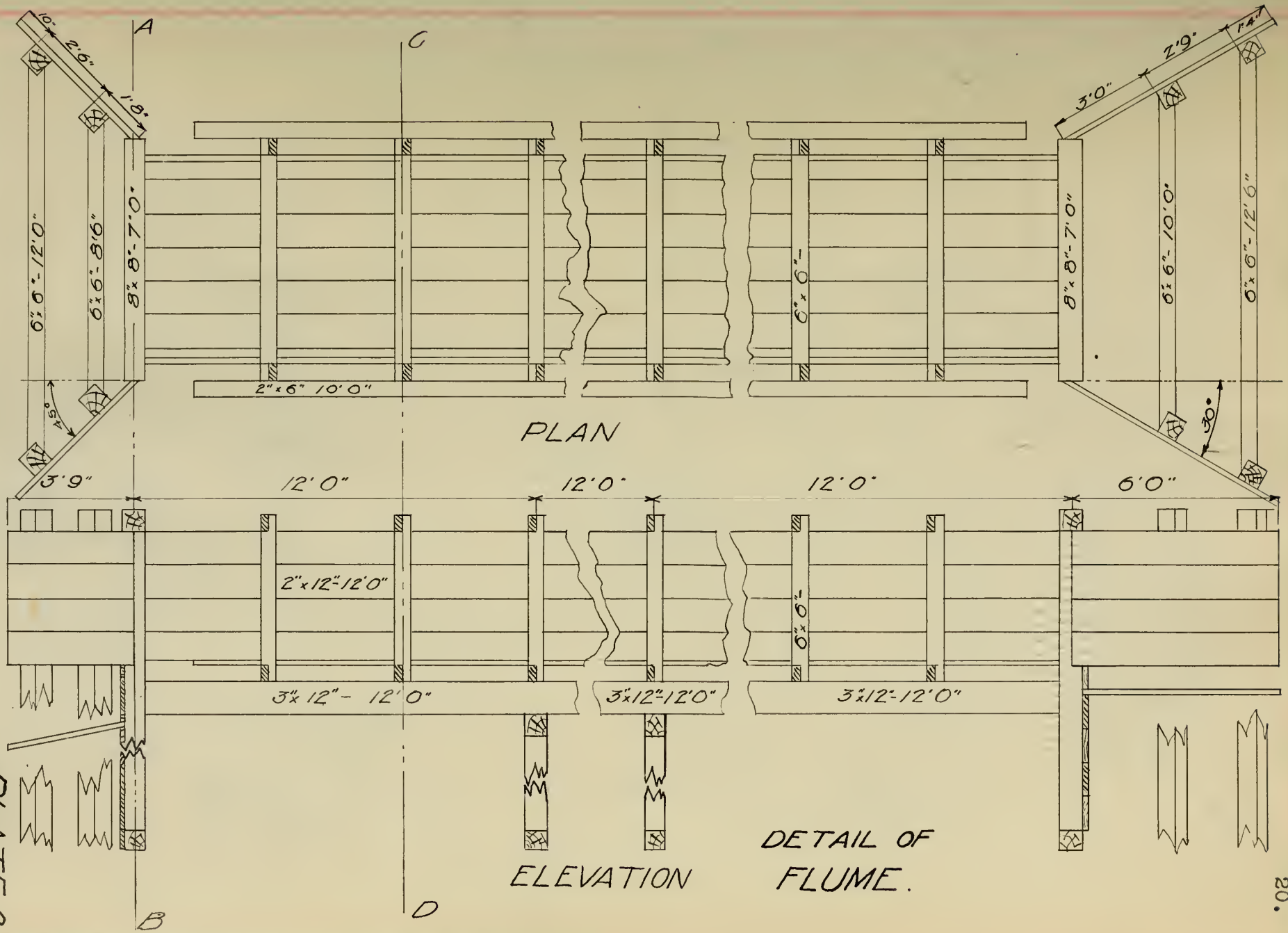
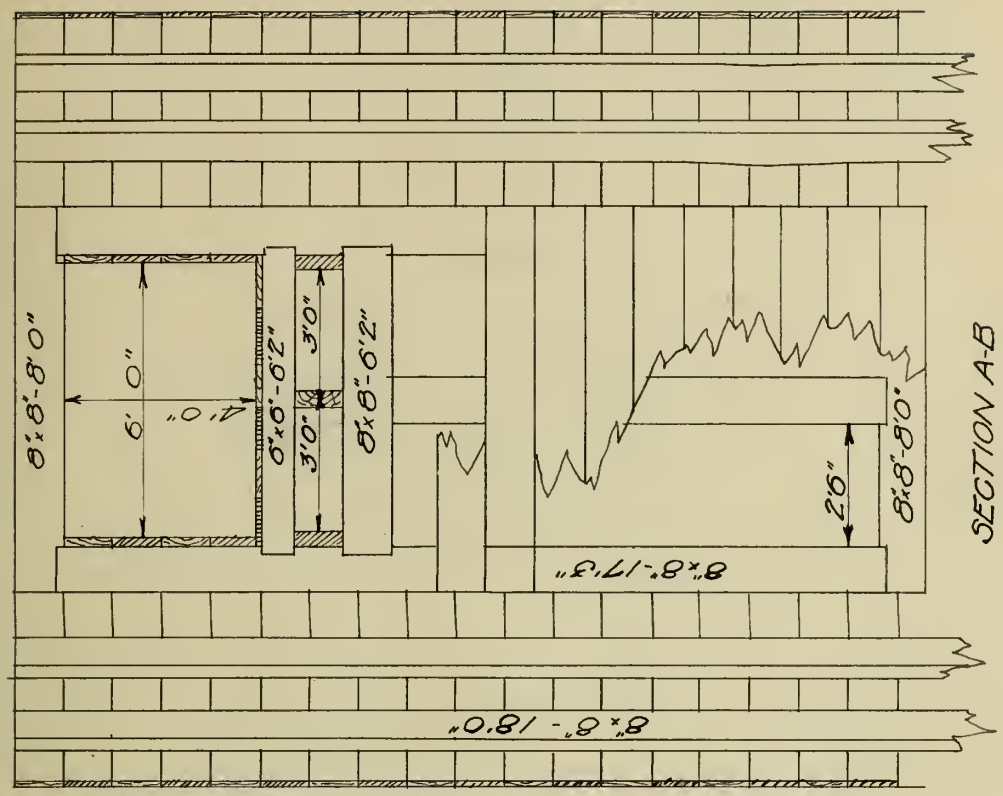
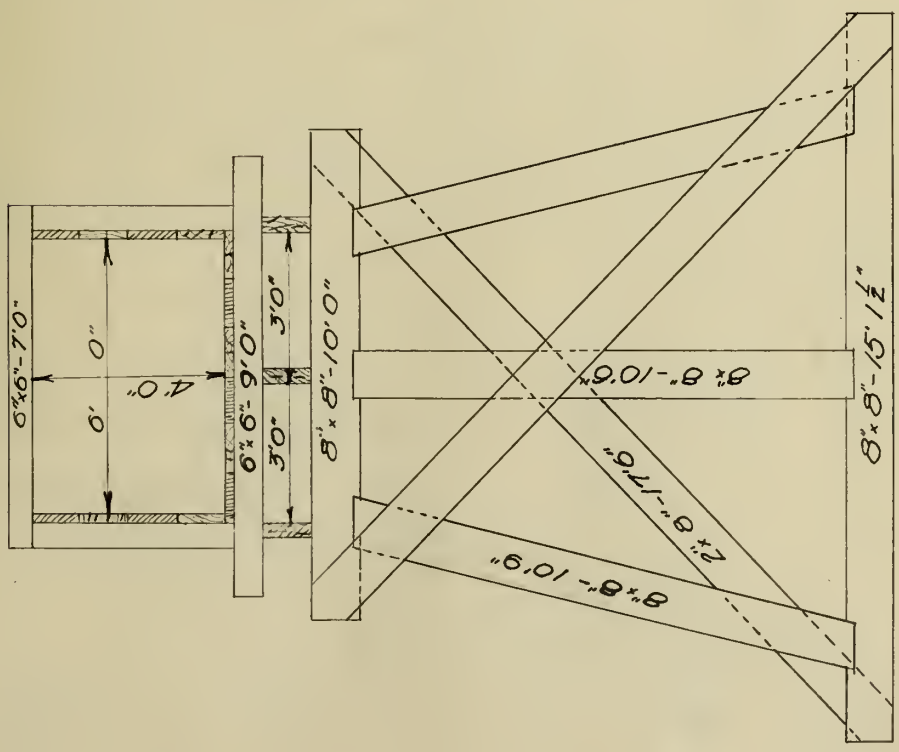

A
C
B
D
10"
2'6"
1'8"
6"x 6"- 12'0"
6"x 6"- 8'6"
8"x 8"- 7'0"
2"x 6" 10'0"
6"x 6"- 10'0"
8"x 8"- 7'0"
3'0"
2'9"
1'4"
6"x 6"- 12'6"
45°
30°
PLAN
3'9"
12'0"
12'0"
12'0"
6'0"
2"x 12"- 12'0"
6"x 6"- 10'0"
3"x 12"- 12'0"
3"x 12"- 12'0"
3"x 12"- 12'0"
ELEVATION
DETAIL OF FLUME.

PLATE 2.

20.



SECTION A-B
OF HEAD



SECTION C-D
OF BENT

PLATE 3.

every tract of land to be irrigated. The size of the laterals are made proportional to the acreage which they are to serve.

Plate III on the following page shows the construction of lateral gates in detail.

Culverts.

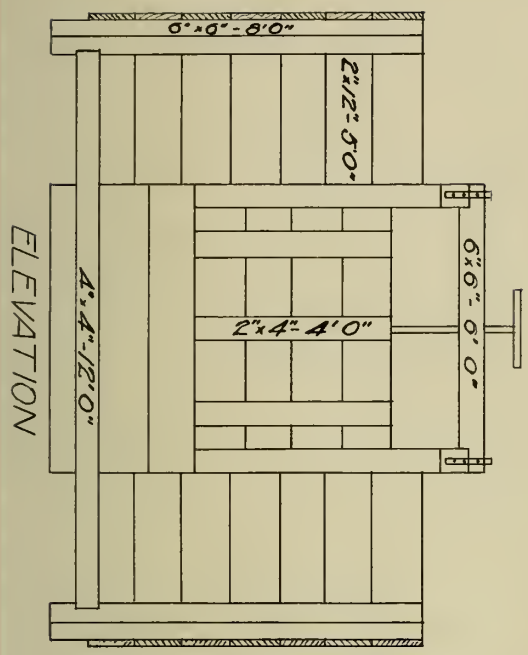
When it is found that considerable water passes the line of the canal at times, and it is thought unadvisable to flume it owing to lack of sufficient clearance from the bottom of the wash to carry the surface water, a box culvert is placed below the grade line and the ditch built over this. There is no fixed rule for determining the size of the culvert, the amount of water being estimated from the banks of the draw and the culvert is desgined on the assumption that this is the maximum amount of water that will ever come down the wash. The top of the culvert is always placed at least two feet below the bottom of the ditch.

Waste Gates.

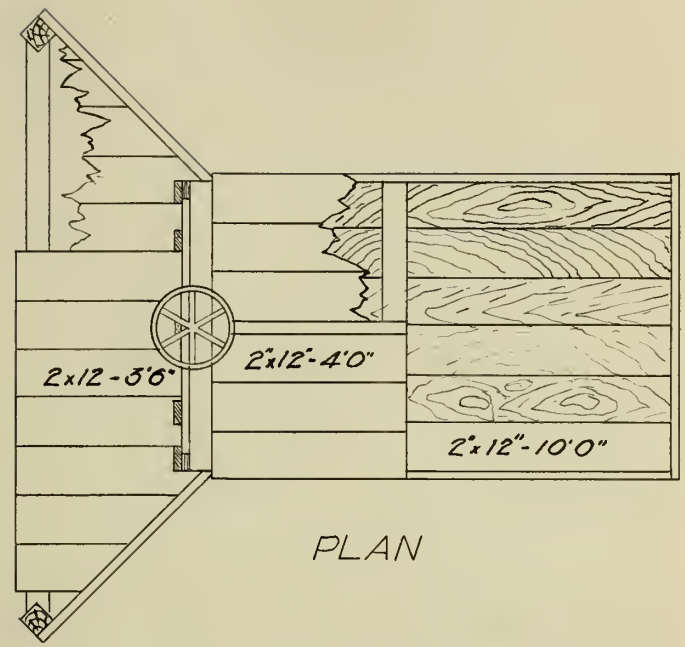
Where the canal crosses a wash or drain, and there is a probability that an excessive amount of water will flow in the wash at certain periods of the year, a waste gate is located at this point, if the wash is neither flumed or a culvert constructed. Waste gates are of the same construction as head-gates, the opening being placed at the highest level allowed in the canal. When the water in the canal rises above this level, it overflows through the waste gates and the banks of the canal are thus relieved.

Fails and Drops.

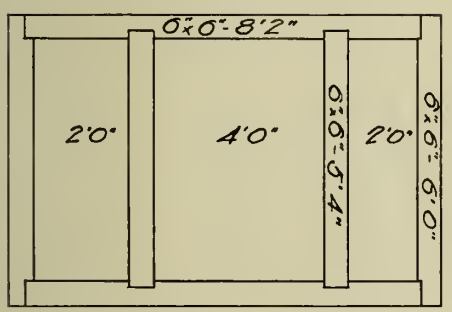
Where the natural fall of the country, through which the

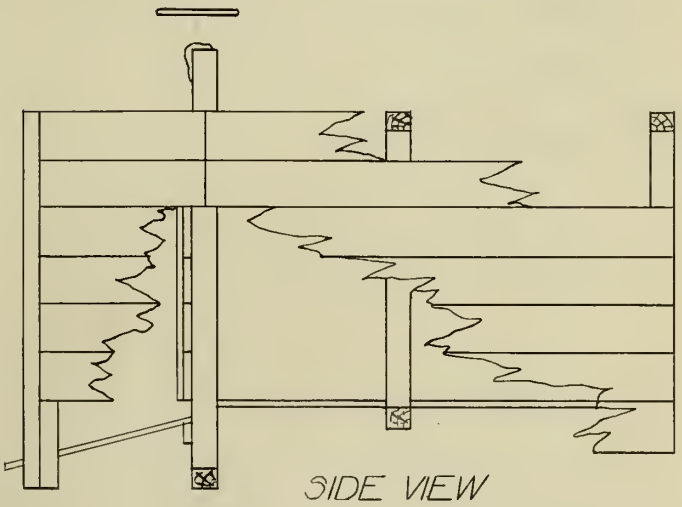


ELEVATION



PLAN





SIDE VIEW

PLAN OF A
LATERAL GATE
THE UINTAH IRRIGATION SURVEY.

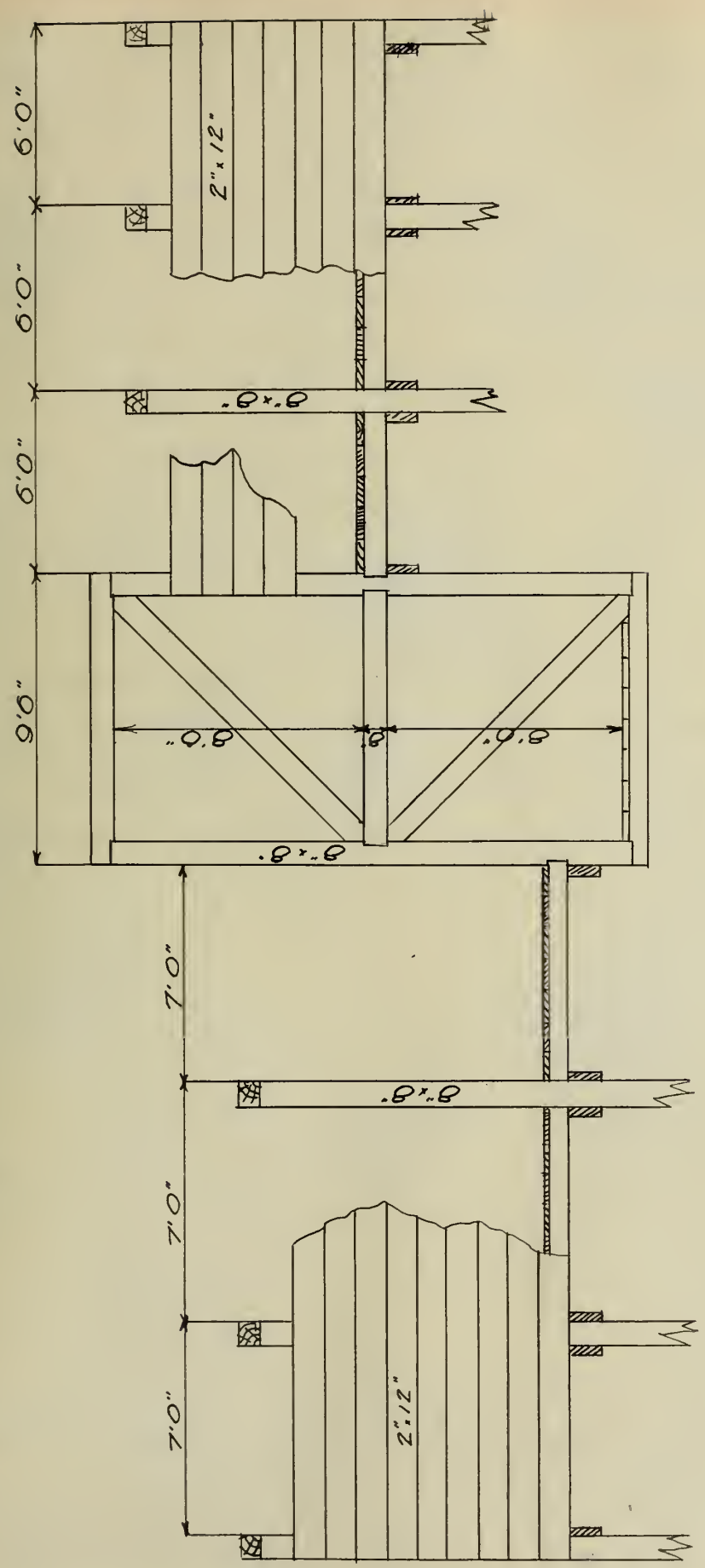
PLATE 4.

canal runs, is greater than the desired slope of the canal, the tendency of the water in the latter is to erode its bed. The erosion produced by the excesive velocity is often very noticeable in small sections of the line. Where the erosive action extends over long stretches of the canal, a series of steps is generally formed which is a direct indication of too much velocity. Where the canal is straight, little harm is done by this erosive action other than to cause the level of the water to sink below the ground surface and thus prevent its diversion into laterals. Where curves occur, this erosive action of the water, will cause them to be cut down and the alignment of the canal will thus be changed. In order to compensate for the slope of the country, drops or vertical fails, are provided in order to reduce the velocity. The location of these drops is usually fixed by the place where the canal comes too high above the surface of the ground. When possible, drops or vertical falls, on account of their expense of construction, and constant care, are avoider by running in the line on a grade contour., but often the increase in distance, is more expensive than running the line on a direct slope and compensating for the difference in grade by the insettion of drops.

The drops employed by the Uintah Irrigation Survey are as in the sketch shown on the following page. It will be observed that at the foot of the drop there is a box arrangement which serves as a water cushion and prevents the erosive action of the water in the lower level at the foot of the fall.

Seepage.

The loss of water from the canal by seepage and evaporation is a matter of very great importance. This is true whether.



CROSS SECTION OF A
VERTICAL DROP

PLATE 5.

the water supply is abundant, or limited. Under the former condidions, although the loss is not directly felt, sooner or later the effect is noticed, in sections lying along the canal, which gradually become swampy and worthless. Under the latter condition, the loss to both the irrigator and canal people is so apparent as to scarsely need mentioning.

In an investigation of this sort, there are always three things to look out for: viz:

1. The amount of loss in given sections of the channel.

2. The exact or approximate location where the loss is greatest, determined by dividing the canal into sections and determining the seepage, in each separately; and,

3. Possible remedies for such losses when determined.

The method for determining the loss in any section of the canal consists of obtaining the inflow at the ypper end of the section and the total outflow from the section, which includes the amount diverted by the laterals as well as the outlow at the end o of the section. The difference between the inflow and the total outflow is the loss. As the time intervening between the upper and lower measurements of any section is in no case more than three or four hours, the amount by evaporation from the canal surface during the period of observation is extremely small, and result of this loss is seldom considered separately, but only as a part of the total loss from all causes.

As the government canals are just being finished, no investigations or measurements of losses such as the above, have been made, but the following table taken from the Government Report of 1901 on the Bear River Canal System, in Utah, will serve to show

the probable losses that exist in the Deep Creek Canal and other canals, as the discharge and character of soil through which the two canals pass is of the same general character.

The section quoted, extends from the headgate to Bridge No. 18, a distance of eight miles, and shows the losses as follows:

Discharge at head gate	109.99
Diversions:	
Box No. 90	2.51
Box No. 95	4.00
Box No. 104	1.75
Box No. 105	.05
Central Lateral	39.81
Box No. 110	30.00
Box No. 115	.40
Box No. 125	5.76
Box No. 130	3.11
Box No. 140	4.57
At Bridge	43.26
Total	195.52
Loss in Section	4.47
Loss per mile	.64
Per cent loss	4.06

At one point along the Deep Creek Canal, the ditch, in climbing a hill, encountered a formation of small cobble stones ranging in size from a small pebble to boulders nearly a foot in diameter. When the water was turned on, in the ditch, nearly all of it disappeared on reaching this point and it was thought for a while that this point of the line would have to be relocated.

An experiment was finally tried by dumping in several wagon loads of fine clay just above the point in question which ultimately sealed up the interstices in the bed of the ditch and allowed the water to flow on uninterrupted.

Ties and Alignment.

After the ditch has been fully completed, it is then meandered by means of stadia and transit, and ties made to every forty acre corner.

Where the line run adjacent to, or parallel with the section, or quarter section line, the ditch is placed on the lower side of the road and two banks are built up to keep the water from overflowing the road. On section lines, the law requires that the ditch must be thirty-five feet from the line. On quarter section lines, twenty feet.

Banks.

The banks are given a 1 1/2 : 1 slope on the outer and a 2 : 1 slope on the inner side, the height and width of the crown depending upon the size of the ditch. When the ditch crosses a large wash or coulee, and neither a flume or culvert is built, the width of thebank is increased from one to three feet, to insure ample protection against heavy rains. Ordinarily, th bank is built on the lower side of the ditch and the upper side left open. As the upper cut is generally equal to or greater than the depth of water to flow, the water seldom leaves the main channel.

On approaches to flumes, two banks are built for several stations to secure the ditch against washouts. Where the ditch approaches a culvert, two banks are here constructed to keep the

surface water from entering the ditch.

Where it is necessary to carry the canal along the side of a hill, the width of the bottom is generally widened and the slope of the bank given a 1 1/2 : 1 slope.

Excess Material, Borrow and Haul.

The excess of cut over fill is figured at 10%. All waste material is placed in the banks and widening them, but not making them any higher than specified, except on through cuts where dirt is put in regular banks on each side of the ditch. Borrow is generally made from bottom of ditch or the upper side of same, but never from the lower side. The haul is from 0 to 150 feet.

Rip-rapping.

Banks at the head gates, are always rip-rapped in or sheet piling driven to protect tem against erosion. The sheet piling is only resorted to where the current will not permit of the rip-rapping. The rock used in rip-rapping is always ledge rock and willows, cobble stone so common to that part of the country, never being used. The objection to using the cobble stones is thatowing to their spherical shape, they tend to roll away when attacked by the swift current of the streams.

Tools.

The tools used in the construction of the ditches consist of tongue scrapers, slips, rooter plows, grubbers, heavy plows, and wing plows.

The tongue scraper is a flat wooden scraper with a wagon tongue attached to the same. By this arrangement the scraper

can be set at any angle and is used principally in finishing the banks.

The slips are of the same construction as the ones found in all railroad work and foundation work.

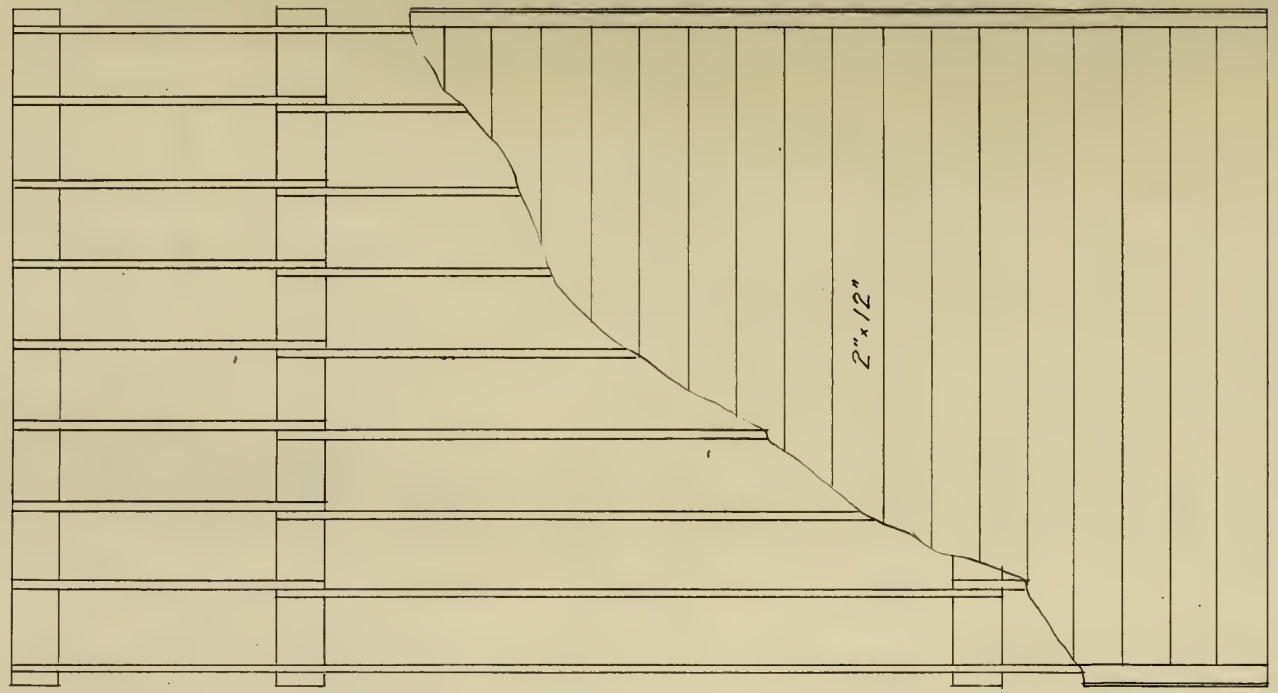
The rooter plow has the same general appearance as the common railroad plow with the exception that the plow share is replaced by a flat vertical plane about three inches thick and brought to a sharp edge. It is used principally in cutting away roots and loosening rock and cement where encountered in the ditch.

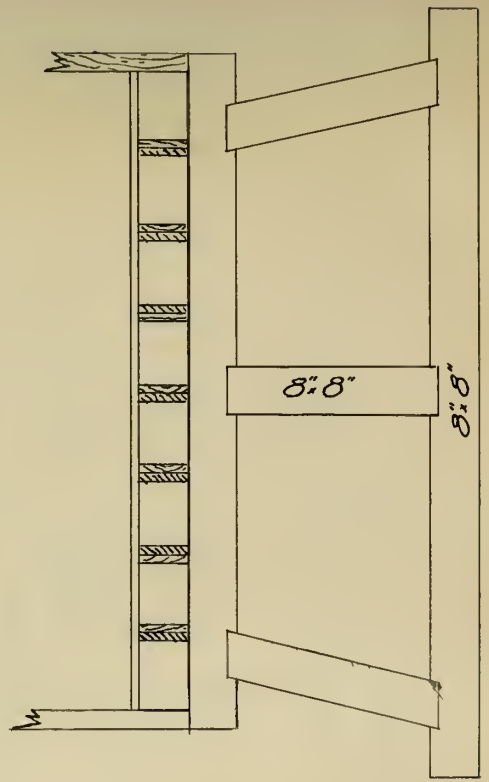
The brubber consists of an I-Beam with thirty two teeth about three and one-half feet long of one and one-half inch square tapered to a point and curved slightly up at the ends, thus preventing the points from catching on the ground surface. It is used principally in removing sage brush, grease wood etc.

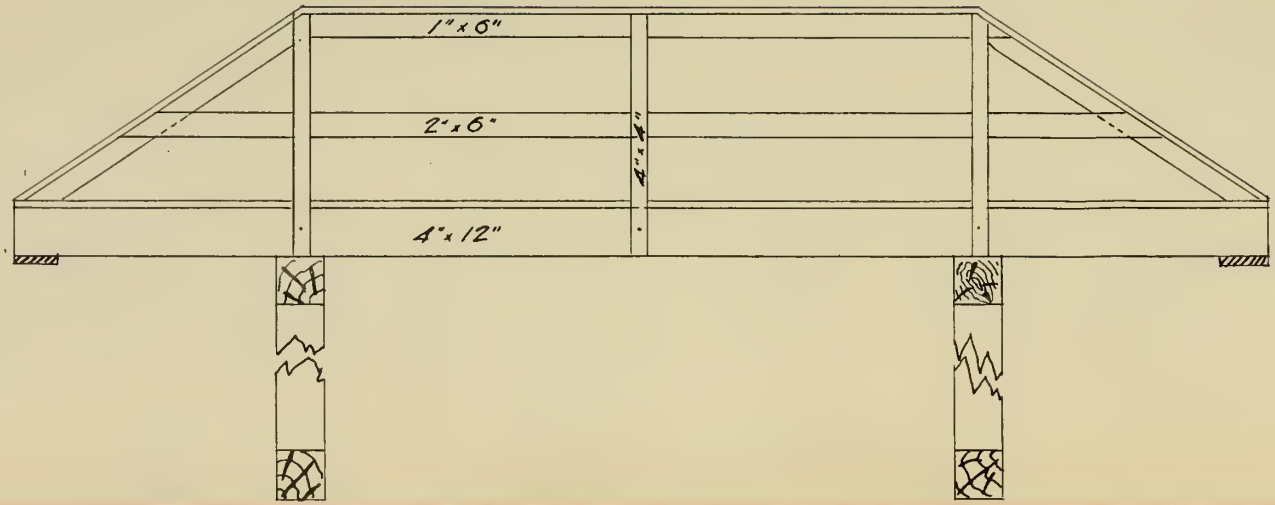
The wing plows are simply double plows that throw dirt to both sides. In shape, it resembles the pilot of a locomotive. It is used principally in the construction of the laterals.

Monthly reports are submitted to the chief engineer giving the amount of work performed with the unit cost of same. Upon the completion of the ditch, a report in detail, giving itemized cost of each of the various important features of the work constructed, is made to the same office.

To determine the unit cost of each and every feature of the survey, the following method of cost-keeping is required.







PLAN OF A
HIGHWAY BRIDGE
UINTAH IRRIGATION SURVEY
UTAH

PLATE 9.

General Expense.

1. Salaries - Superintendent and Clerk.
2. Telephones.
3. Telegraph.
4. Office Supplies - Printing and Stationery.
5. Traveling - Local.
6. Office - Light, Heat and Janitor Service.
7. Furniture - Fixtures and Repairs.
8. Traveling - Superintendent (Other than local)
9. Repairs to Office Buildings.

Engineering.

11. Labor.
12. Salaries - Engineering.
13. Forage.
14. Material.
15. Camp Equipment.
16. Instruments.
17. Repairs - Harness, Tents, Etc.
18. Drafting.

Maintenance of Camps.

20. Moving Camps.
21. Building Roads - Labor.
22. Repairing Tents, Etc.
23. Material.
24. Equipment.
25. Hauling Water and Wood.
26. Cooks and Helpers.

27. Blacksmith - Labor.

28. Hauling Supplies.

Buildings.

30. Material - Lumber.

31. Hardware.

32. Labor - Carpenters.

33. Labor - Laborers.

35. Repairs.

36. Rent.

Telephone Lines.

40. Labor - Laborers.

41. Labor - Teams.

42. Material.

43. Telephones.

Corral Expenses.

50. Forage.

51. Labor.

52. Repairs to Harness - Material and Labor.

53. Repairs to Harness - Wagons, Material and Labor.

54. Material.

55. Equipment.

56. Veterinary Hire and Supplies.

57. Horses and Mule Loss.

58. Blacksmith - Labor.

Clearing and Grubbing.

60. Clearing - Labor.

61. Grubbing.

62. Temss.

63. Material.

Excavation Class.

70. Labor - Forage.

71. Labor - Timekeepers.

72. Plowing - teams.

73. Plowing - holders.

74. Slips - teams.

75. Slips - holders.

76. Slips - dumpers.

77. Tongue scrapers - teams.

78. Tongue scrapers - holders.

79. Fresnos - teams.

80. Fresnos - holders.

81. Fresnos - dumpers.

82. Finishers - teams.

83. Finishers - labor.

84. Labor - laborers.

85. Draining.

86. Tools - all kinds.

Excavation Class 2.

90. Labor - foreman.

91. Labor - timekeepers.

92. Plowing - teams.

93. Plowing - holders.

94. Slips - tongue.

95. Slips - holders.

96. Slips - dumpers.

97. Tongue Scrapers - teams.

98. Tongue Scrapers - holders.

99. Fresnos - teams.

100. Fresnos - holders.

101. Fresnos - dumpers.

102. Finishers.

103. Rockmen.

104. Labor - laborers.

105. Explosives.

106. Tools - all kinds.

Excavation Class 3.

110. Labor - foreman.

110. Labor - timekeepers.

111. Labor - teams.

112. Labor - laborers.

113. Rockmen.

114. Explosives.

116. Material.

117. Equipment.

Timber Construction.

130 Labor - foreman.

131. Labor - timekeepers.

132. Labor - carpenters - framing.

133. Labor - carpenters - erecting.

134. Labor - excavation.

135. Labor - teams excavating.

136. Labor - back filling.

137. Labor - teams back filling.

138. Labor - puddling.

139. Hauling material.

140. Miscellaneous.

141. Material - lumber.

142. Material - hardware.

143. Tools - all kinds.

144. Repairs.

Quarrying.

200. Labor - foreman.

201. Labor - rockmen.

202. Labor - derrickmen.

203. Labor - laborers.

204. Labor - teams.

205. Explosives.

206. Equipment.

207. Stripping quarry.

208. Repairs.

Rip-rapping.

230. Labor - foreman.

231. Labor - laborers.

232. Labor - timekeepers.

233. Labor - collecting.

234. Labor - placing.

235. Labor - teams hauling.

236. Labor - materials.

Saw-mill.

240. Labor - sawyer.

241. Labor - engineer.

242. Labor - laborers.

243. Labor - teams.

244. Repairs.

245. Equipment.

246. Moving.

247. Material.

248. Logging - labor.

249. Tools - all kinds.

Stream Gauging.

250. Salaries.

251. Equipment.

252. Instruments.

253. Material.

254. Labor.

Note: Excavation Class 1., includes all materials that can be plowed with an ordinary four-horse plow; also, any material that can be handled with scrapers without plowing.

Excavation Class 2., includes hard materials of all kinds that cannot be plowed as described under Class 1, but that requires loosening by powder or otherwise, and can then be removed by scrapers. Class 2 excavation also includes all detached masses of rock more than two and less than ten cubic feet in volumn.

Excavation Class 3, includes all work that does not come under the head of Class 1 or Class 2 that requires drilling or blasting for its removal.

Wet excavation is designated by prefixing the letter "W" to the proper account number.

Conclusion.

The money to build this great work comes not from direct taxation or appropriation, but from the accumulated sums paid for the public lands which are being disposed of in these states and territories. Day by day, the settlers or investors are paying the Government small sums, to obtain a complete title oto lands which have been in public ownership. A half to seven tenths of the total area of the Western States and territories still belongs to the United States. The Government is giving away or disposing of these lands as it has been for generations, and the money received is credited in the Treasury to the Reclamation Fund to be used for the construction of great works which will enable a better disposal of thepublic lands and a creation of a vast number of small farms instead of a few large cattle ranches.

The arid lands virtually pay for their own reclamation and the Government is the gainer by bringing about a permanent and prosperous settlement of areas which otherwise would have been condemed to perpetual sterility.

Under wise administration, arid America has a glorious future. With her countless small farms and rural homes, communities where people live in the open air, till the soil with

their hands, and yet enjoy the privileges and advantages of the city, she will prove the sheet anchor of the republic in any time of national peril, which from her will radiate eastward the same idea of the division of the larger into small farms and the utilization of the streams and ponds in making certain and increasing an oftentimes unreliable crop.